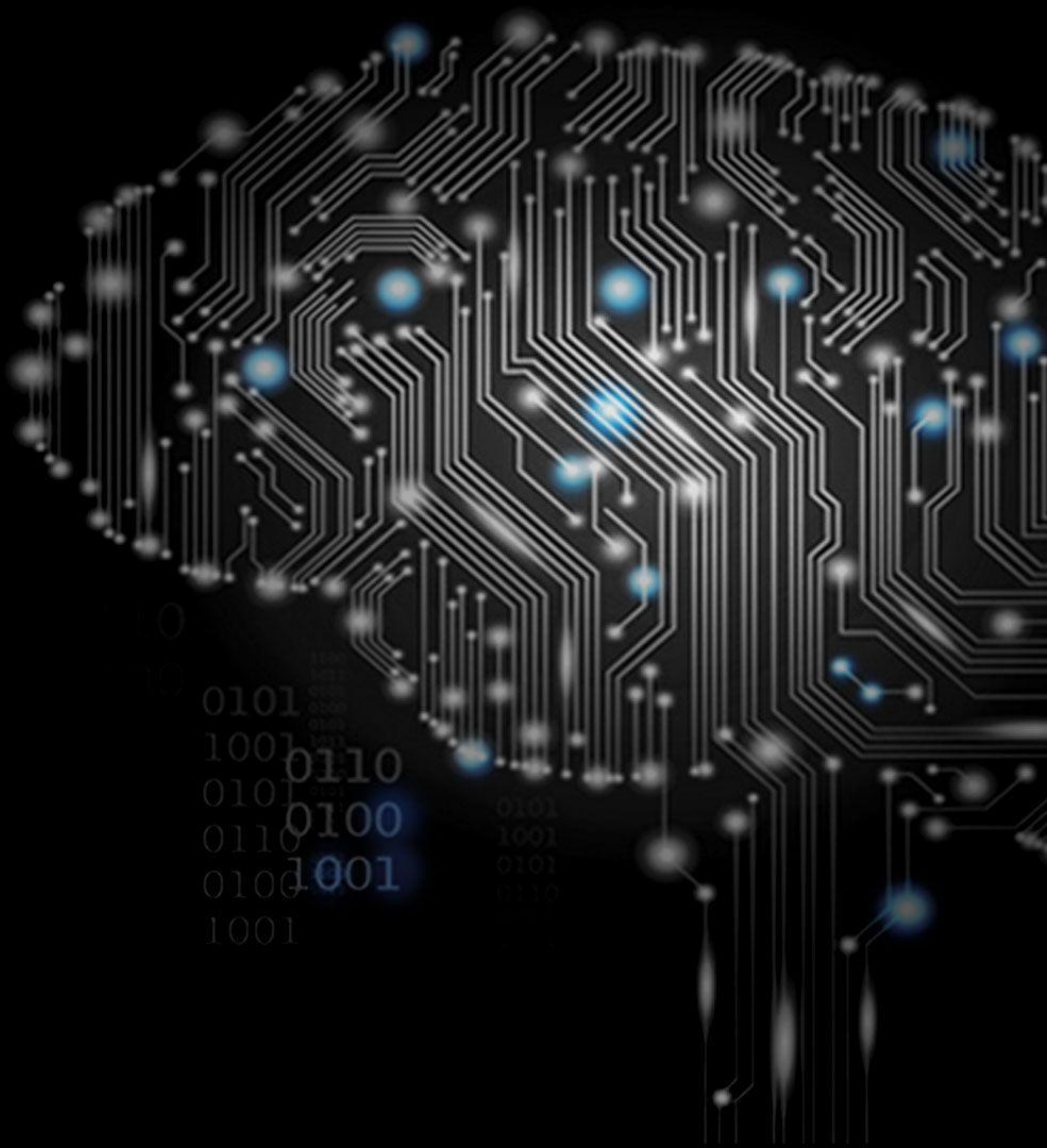
دانشگاه سیستان و بلوچستان

An Introduction to Krill Herd Algorithm

Course Title: Computational Intelligence (2014335)
Course Instructor: Dr. M Rezaei
Student: Ali Abbasi, Dorsa Sayadi

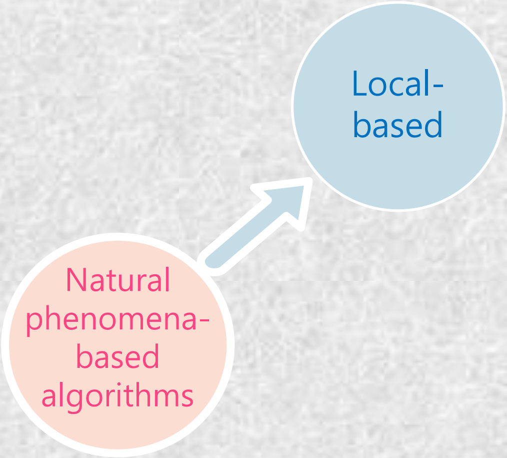
April 2021

Faculty of Electrical and Computer Engineering,
University of Sistan and Baluchestan, Zahedan, Iran



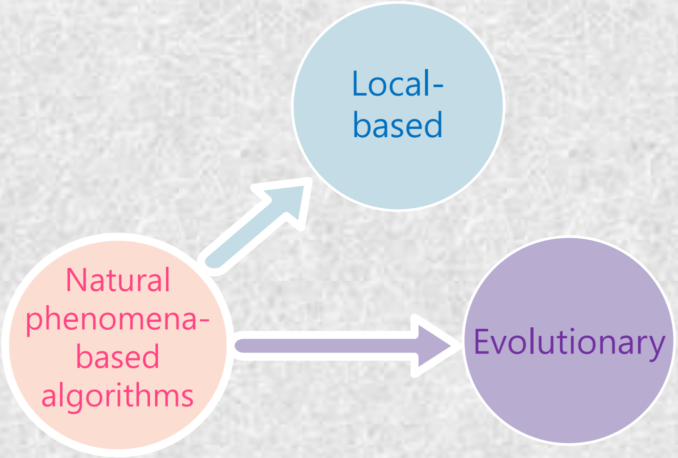
Content

Introduction



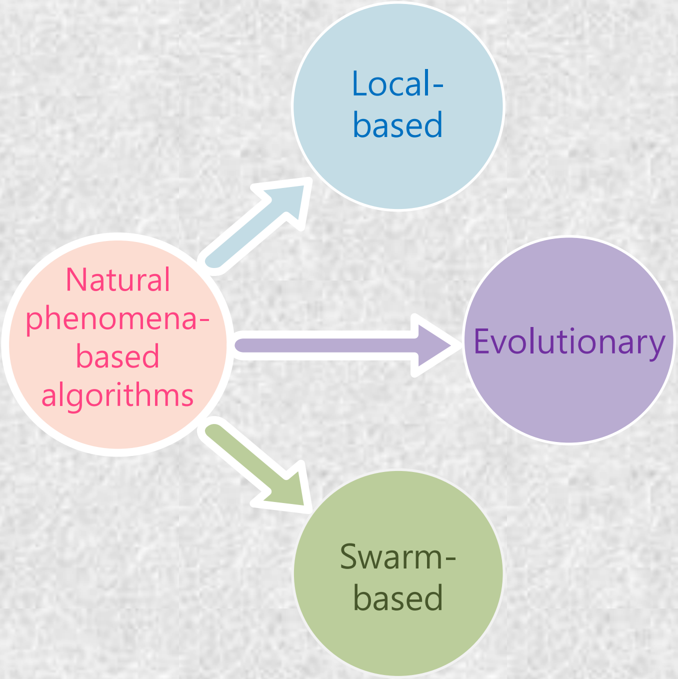
- A **single** provisional solution
- Iteratively **improved** until a stagnation point in the same area of the initial solution is reached
- Examples:
  Simulated Annealing, Tabu Search, Variable Neighborhood Search, and Hill Climbing.

Introduction



- A **set** of **random** individual
- Iteratively **recombine** the solutions and follow the survival of the fittest principle until the acceptable solution is reached
- Examples:
  Genetic Algorithm, Harmony Search Algorithm, Genetic Programming.

Introduction

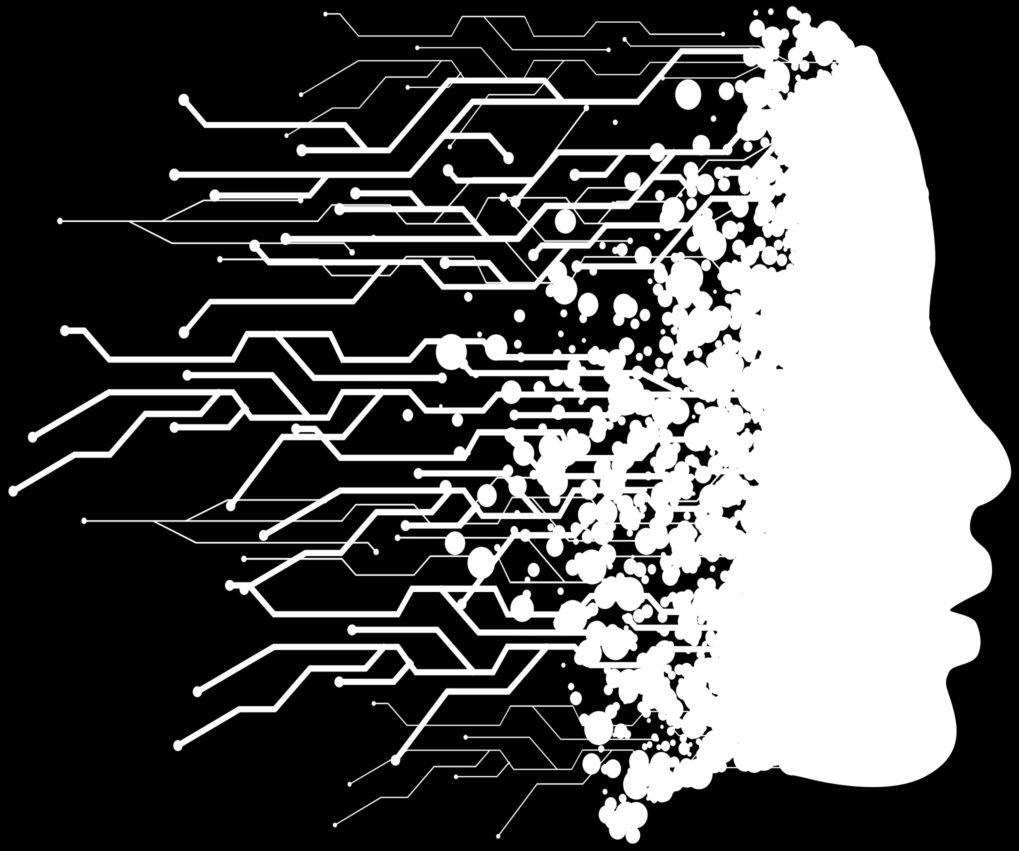


- A **set** of **points**
- The solutions are normally **constructed** based on **historical information** gained by **previous** generations
- Examples:

  Artificial Bee Colony Algorithm, Bacterial Foraging Algorithm, Biogeographical-based Optimization, Cuckoo Search Algorithm, and Firefly Algorithm

General Structure of KH Algorithm

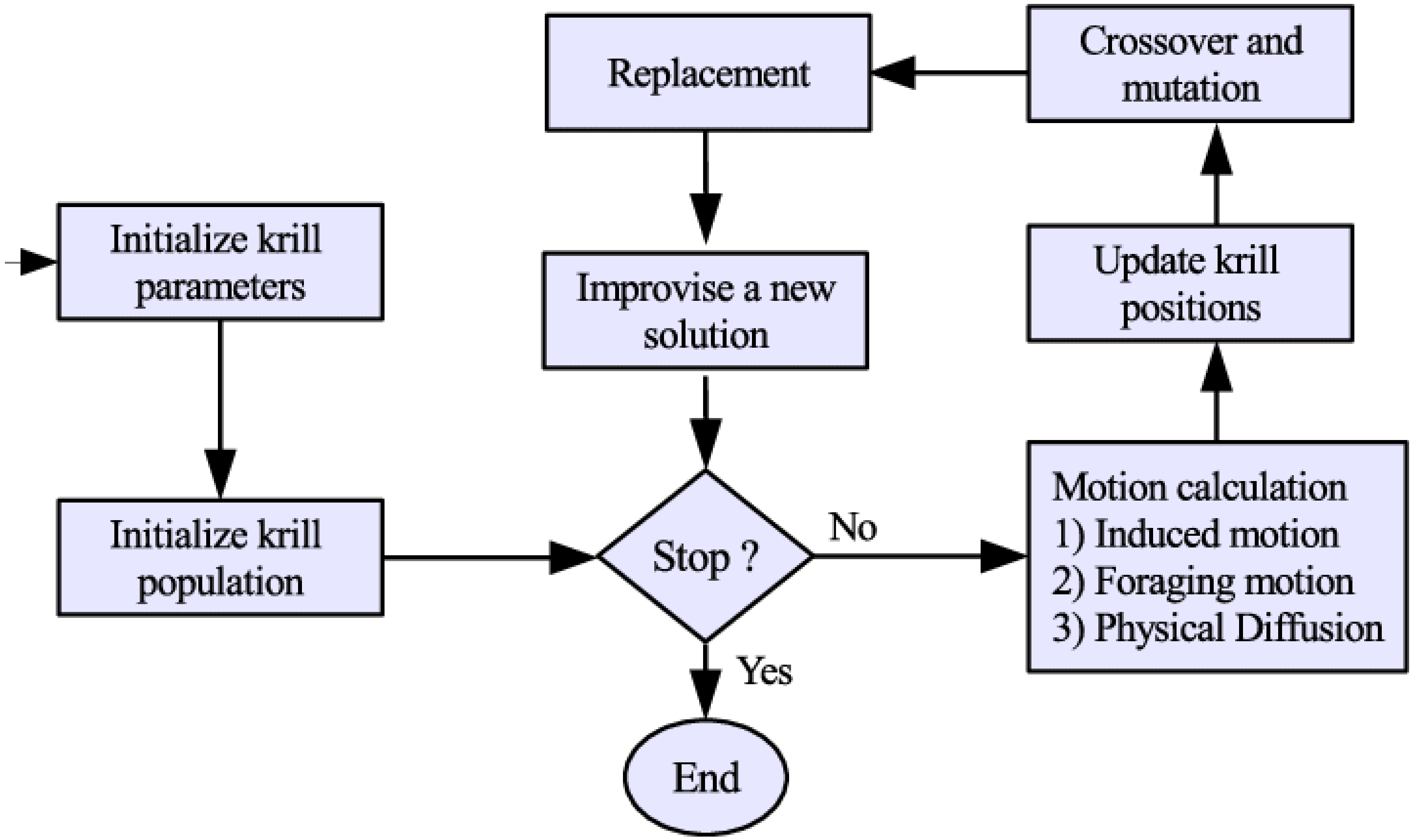
- ❖ Motion Induced Process
- ❖ Foraging Movement
- ❖ Random Physical Diffusion
- ❖ Position Update
  - Crossover
  - Mutation



General Structure of KH Algorithm

- It is a **swarm intelligence** search algorithm that is motivated based on the **herding behavior** of krill individuals.
- The **objective function** for the movement of krill is measured by the **shortest distance** of each individual krill from **food** and **highest density** of the herd.
- Each individual in KH algorithm modifies its **position** based on three **operational process**: (1) **motion** induced by other individuals (2) **foraging movement** and (3) **random** physical diffusion.
- The KH algorithm is being referred to as a powerful search technique because it **contains** both **exploration** and **exploitation** strategies based on foraging movement and the motion induced by other individuals respectively.
- As a swarm intelligence technique with a lot of advantages, it combines the efficient operations of evolutionary-based algorithm utilizing **crossover** and **mutation** components within its framework and thus makes the search framework stronger.

Krill Herd Algorithm



Motion Induced Process

- The velocity of individual Krill is influenced by the **movement** of **other** Krill in the multi-dimensional search space where its velocity is dynamically perturbed based on **local** effect, **target swarm** effect and repulsive swarm effect.

$$\theta_i^{new} = \epsilon_i \theta_i^{\max} + \mu_n \theta_i^{old}$$

where

$$\epsilon_i = \epsilon_i^{local} + \epsilon_i^{target}$$

$$\epsilon_i^{local} = \sum_{i=0}^{Ns-1} f_{ij} x_{ij}$$

Note that

$$f_{ij} = \frac{f_i - f_j}{f_w - f_b}$$

$$x_{ij} = \frac{x_i - x_j}{|x_i - x_j| rand(0,1)}$$

$$\epsilon_i^{target} = 2\left(rand(0,1) + \frac{i}{i_{\max}}\right) f_i^{best} x_i^{best}$$

$\theta_i^{\max}$ → Maximum induced motion

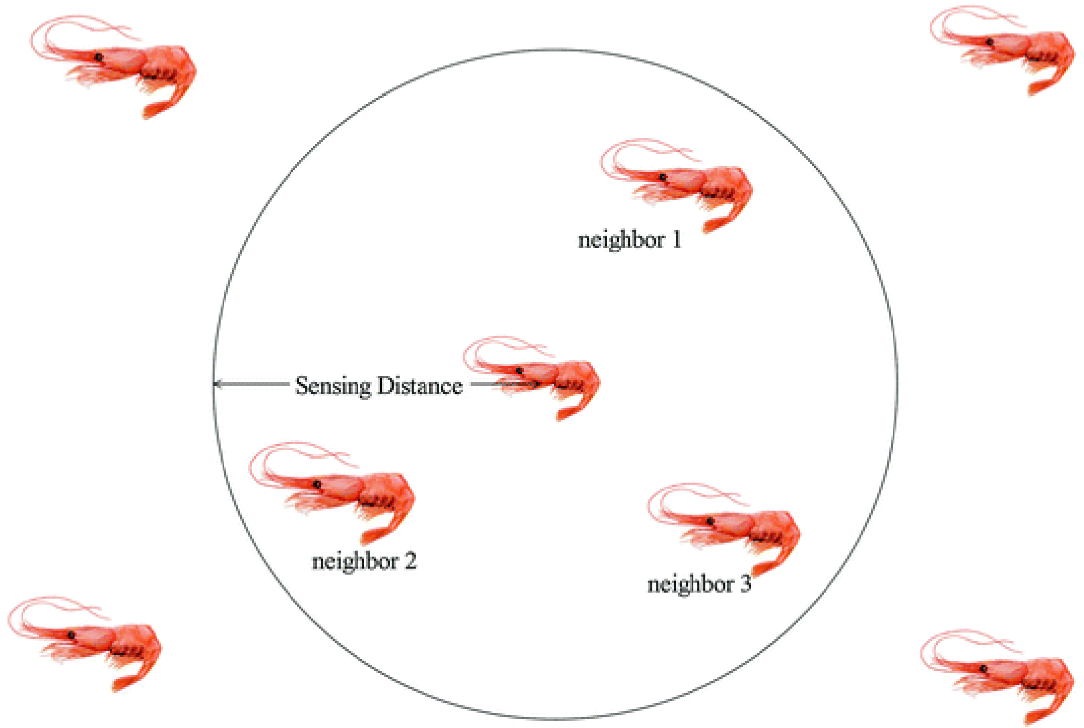
θ_i^{old} → The last induced motion

μ_n → Represents the inertia weight of the motion induced

ϵ_i^{local} and ϵ_i^{target} → Local and target effects

f_w and f_b → Worst and best position of the population

Motion Induced Process



$$SD_i = \frac{1}{5n_p} \sum_{i=0}^{n_p-1} |x_i - x_j| \quad (7)$$

Foraging Movement

- The foraging movement of each individual krill is formulated in terms of the **current food location** and the **previous knowledge** about the food location.

$$F_m = V_f a_i + \mu_f F_m^{old}$$

where

$$a_i = a_i^{food} + a_i^{best}$$

F_m → The first movement

V_f → The foraging velocity

μ_f → The inertia weight of the foraging movement in (0,1)

F_m^{old} → The previous foraging movement

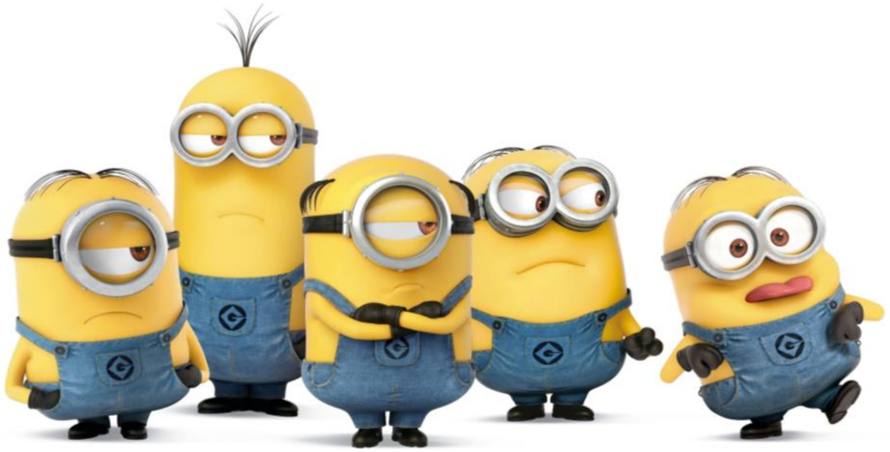
a_i^{best} → The food attractive

a_i^{food} → the effect of the best fitness of the each individual krill

Random Physical Diffusion

- In KH algorithm, the **population diversity** is **enhanced** with the aid of random diffusion process that is integrated in krill individuals. The mathematical expression of the random diffusion process in terms of a maximum diffusion **speed** and a random **directional factor** that follows:

$$RD_i = RD^{\max}\vartheta$$



Position Update: Crossover - Mutation

Crossover:

- In this phase, each member of krill update its current position using the position of others in accordance with the position update equation.

$$x_{ij} = \begin{cases} x_{rj} & \text{if} \quad rand(0,1) < C_{R_i} \\ & \text{where} \quad r = 1, 2, \ldots, n_p; r \neq i \\ x_{ij} & otherwise \end{cases}$$

$$C_{R_i} = 0.2 f_i^{best}$$

Mutation:

- The usage of the mutation operator is determined by a mutation rate parameter (M_R). The mutant solutions X_{ij} changing the solution X_{best_j} with the difference of two other randomly selected vectors X_{nj} and X_{pj}

$$x_{ij}^{mutant} = x_{BESTj} + M_R(x_{nj} - x_{pj})$$

$$x_{ij}^{mod} = \begin{cases} x_{ij}^{mutant} & \text{if} \quad rand(0,1) \leq M_R \\ x_{ij} & \text{otherwise} \end{cases}$$

$$M_R = \frac{0.05}{F_i^{BEST}}$$

Basic krill-Inspired Algorithm

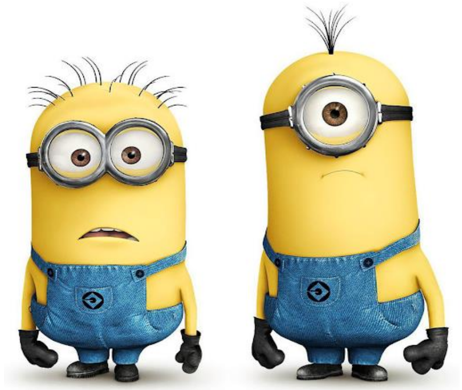
Initialization of Krill parameters: V_f, RD^{max}, θ^{max}, C_R, M_R, and n_p.
for $j - 1$ to n_p **do**
  for $i - 1$ to d **do**
    $x_{ij} - LB_i + (UB_i - LB_i) \times U(1, d)$ {Initialization of krill population}
  end for
  Compute f_j {Evaluate each krill}
end for
Sort the krill and find $\boldsymbol{x}^{best}$, where $best \in (1, 2, \ldots, n_p)$
while $t < Max\_iterations$ **do**
  for $j - 1$ to n_p **do**
    Perform the three motion calculation using Eqs (1), (8) and (10)
    $x_j(t + \delta t) = x_j(t) + \delta t \frac{dx_j}{dt}$ {Update each krill}
    Fine-tune x_{j+1} by using krill operators: Crossover and mutation
    Evaluate each krill by x_{j+1}
  end for
  Replace the worst krill with the best krill.
  Sort the krill and find $\boldsymbol{x}^{best}$, where $best \in (1, 2, \ldots, n_p)$
  $t - t+1$
end while
Return $\boldsymbol{x}^{best}$

Did You Know ?

- The KH algorithm can be used for the training artificial neural networks.

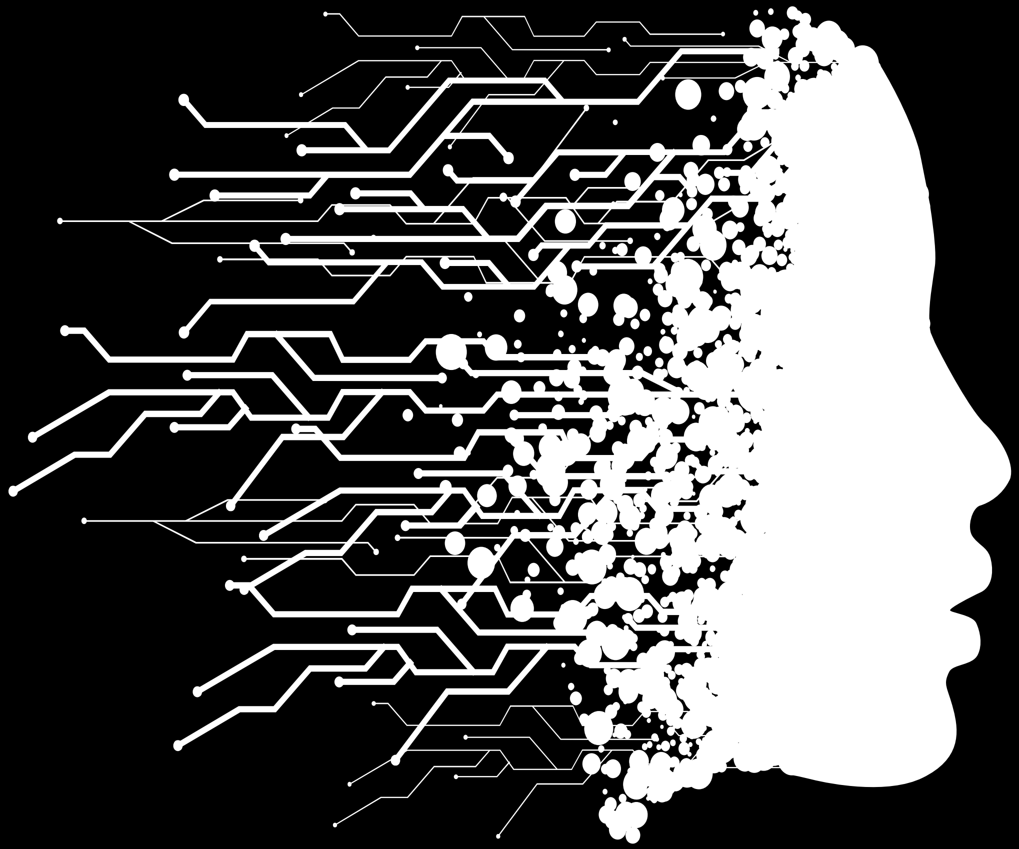
- The emergence of artificial neural networks as an important tool in the domain of artificial intelligence and optimization could not be over emphasized.

- Using KH algorithm, it can be concluded that it produces promising results in terms of classification error (CE), sum of square errors (SSE) and time taken for the training of the ANN.



Modification of Krill Herd Algorithm

- Binary-Based KH Algorithm
- Chaotic-Based KH Algorithm
- Fussy-Based KH Algorithm
- Discrete-Based KH Algorithm
- Opposition-Based KH Algorithm



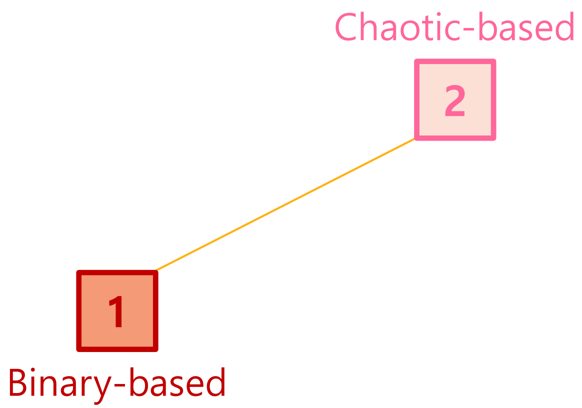
Modifications Of Krill Herd Algorithm

1

Binary-based

- The krill individuals are position to the **binary coordinates**.
- The proposed technique **outperforms** three other approaches when evaluated on several feature selection datasets .

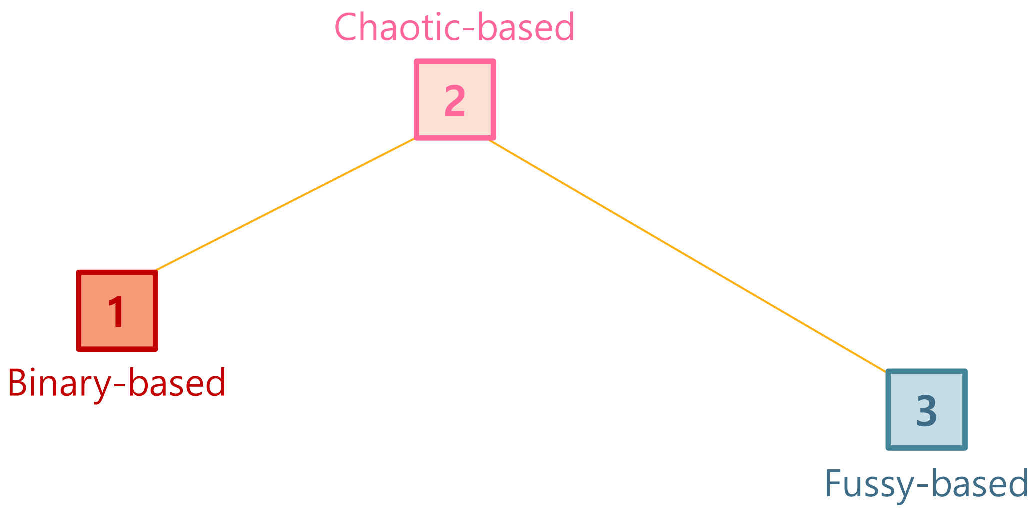
Modifications Of Krill Herd Algorithm



- The various **chaotic maps** are utilized to change the three main movements of the KH algorithm during the **search** process.

- It is found that modified KH algorithm **performs** better than the classical KH algorithm.

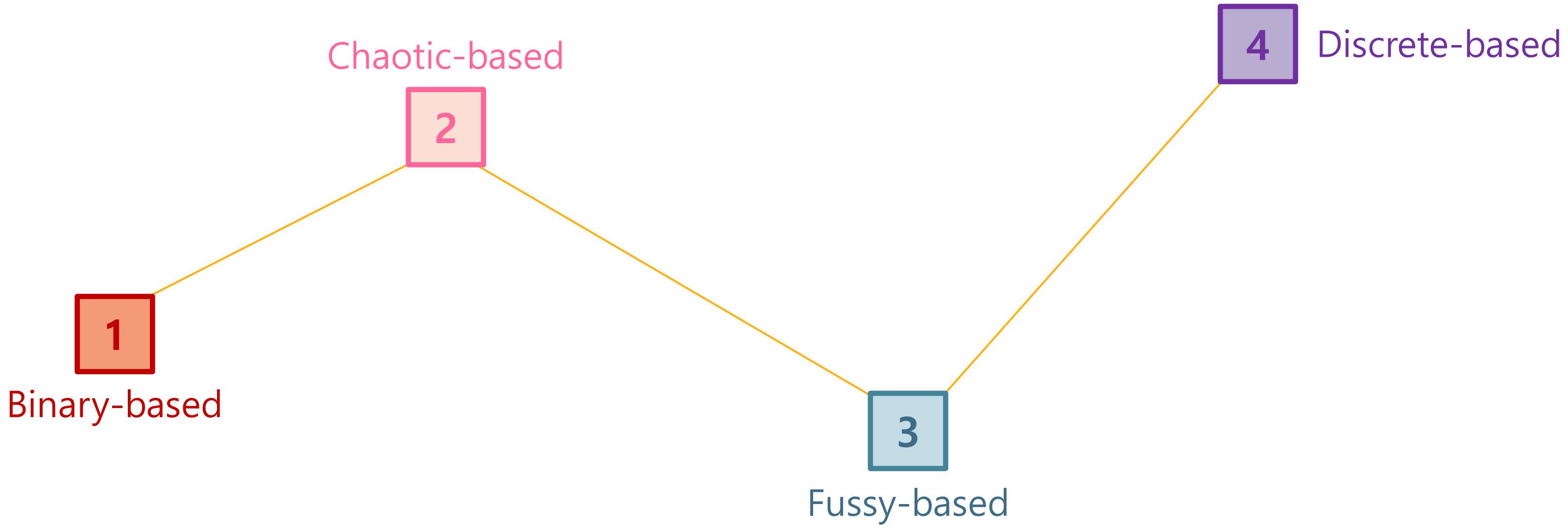
Modifications Of Krill Herd Algorithm



- The **performance** of the KH algorithm could be more powerful, if it is integrated with **fuzzy sets theory**.

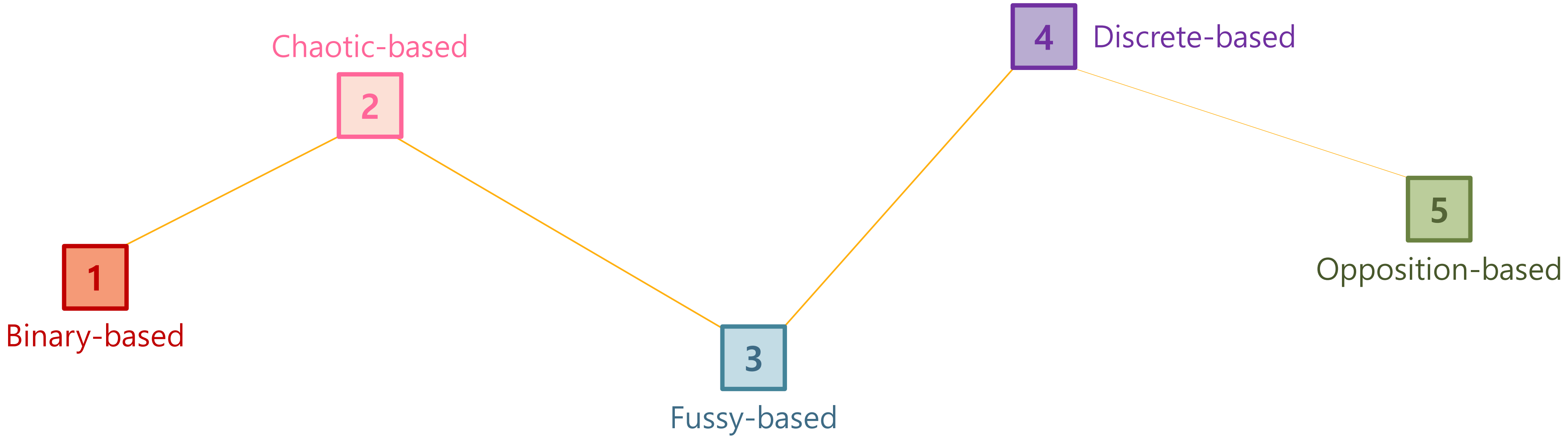
- Proposed fuzzy-based KH algorithm where fuzzy system is utilized to finetune the parameters during the search cycle to strike a **balance** between the **exploration** and **exploitation** capabilities while solving the problems.

Modifications Of Krill Herd Algorithm



- The **continuous** nature of the algorithm was modified to cope with the optimization problems of **discrete** variables.
- The performance of the KH algorithm is better when it comes to **decision making** and **path planning** for graph-based **network** and other discrete event based optimization problems.
- The flexible job-shop scheduling problem (**FJSSP**) is solved with discrete KH method where some **heuristic strategies** are incorporated in order to develop an effective solution approach.
- It also introduced **elitism** strategy into their proposed method to drive the krill swarm towards the better solutions during the search.

Modifications Of Krill Herd Algorithm

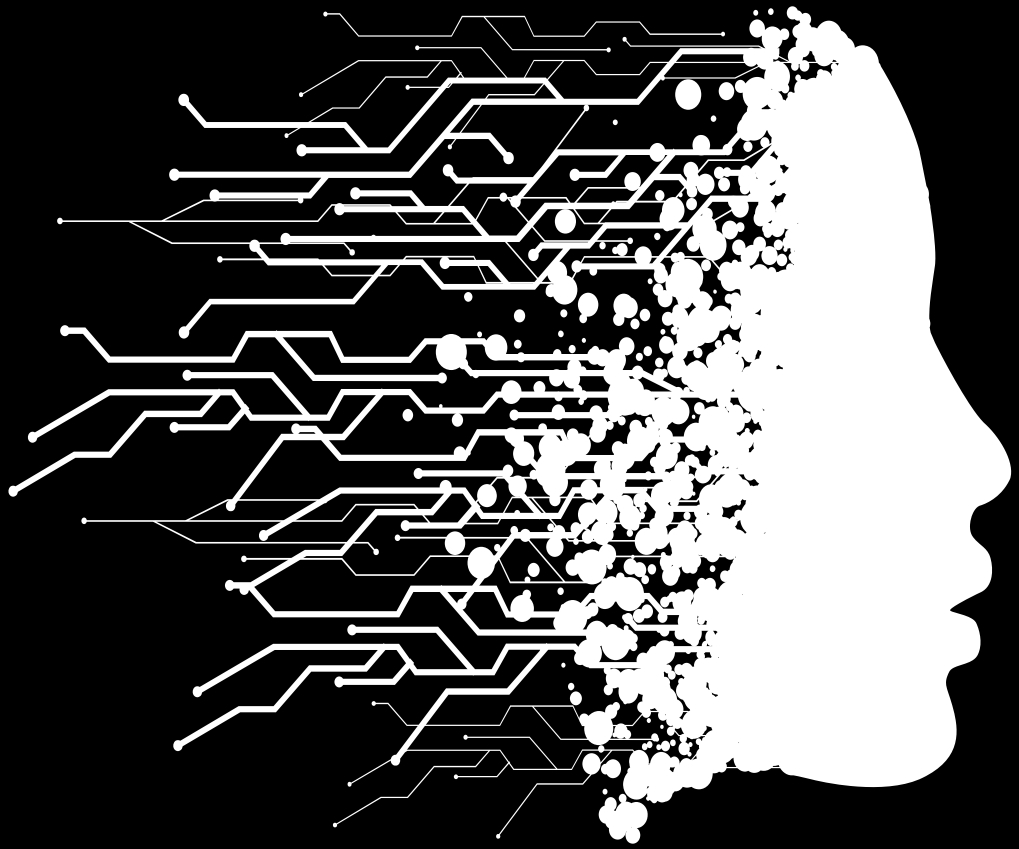


- The introduction of opposition based learning (OBL) strategy and free search operator into the KH algorithm (FSKH), each **krill** member can **explore** the space based on its own **perception** and scope of **activities**.

- The usage of free search strategy is to aid the individuals from being trapped in **local optima**, assists in the **improvement** of **exploration capability** and the **diversity** of the krill **population**. Thus, the modification aided the FSKH to strike a right balance between local **exploitation** and global **exploration**.

Hybridization of Krill Herd Algorithm

- Hybridization With Local-Based Search Algorithm
- Hybridization With Population-Based Algorithm



Hybridization with Local-Based Search Algorithm

- The population-based approaches likes KH algorithm are strong in the **scanning** the search space of **multiple regions** at the **same time**. However, it is not that efficient in **navigating** each region **deeply**.

- Local search-based algorithm is very efficient in **deeply navigating** a **single search** space region but cannot scan the **whole** search space **regions**.

- The **hybridization** of local search within the population search algorithm is very promising to complement the advantages of both types in a **single optimization algorithm** .

- The main aim of this type of hybridization is to strike the right **balance** between a wide range **exploration** and nearby **exploitation** of the problem search space.

Hybridization with Population-Based Algorithm

- The **hybridization** of KH algorithm with operators of other **population-based** algorithms in order to **improve** its **performance** when utilized for complex optimization problems.

- For example combining the **exploitation** of the employed bee component from global best artificial **bee colony** (GABC) with the **exploration** capability of the **KH algorithm** in order to generate the good solutions during the search process. the hybrid algorithm significantly performs better than the basic KH algorithm for all problems.

- The **performance** of the KH algorithm for solving global optimization is **recently** improved with **harmony search** (HS) in, where the HS is employed instead of **physical diffusion** to alter krill **movement** during the **process** of **krill updating** in the KH algorithm.

- It is worthy to mention that the proposed hybrid method effectively combined the global **exploration** of the **HS** with the local **exploitation** of the **KH** algorithm.

References

- S. Kirkpatrick, Optimization by simulated annealing: quantitative studies, J.Stat. Phys. 34 (5–6) (1984) 975–986.
- F. Glover, Tabu search-part I, ORSA J. Comput. 1 (3) (1989) 190–206.
- P. Hansen, N. Mladenovic, J.A.M. Pérez, Variable neighbourhood search, Inteligencia Artificial, Rev. Iberoam. Intel. Artif. 19 (2003) 77–92.
- J.H. Holland, Adaptation in Natural and Artificial Systems, The University ofMichigan Press, Ann Arbor, 1975.
- Z.W. Geem, J.H. Kim, G. Loganathan, A new heuristic optimization algorithm: harmony search, Simulation 76 (2) (2001) 60–68.
- J.R. Koza, Genetic Programming: On the Programming of Computers by Meansof Natural Selection, 1, MIT press, 1992.
- D. Karaboga, An idea based on honey bee swarm for numerical optimization,Tech. rep, Technical report-tr06, Erciyes University, Engineering Faculty,Computer Engineering Department, 2005.
- D. Simon, Biogeography-based optimization, IEEE Trans. Evolut. Comput. 12(6) (2008) 702–713.
- X.-S. Yang, S. Deb, Cuckoo search via lévy flights, in: World Congress on Nature& Biologically Inspired Computing, NaBIC 2009, IEEE, 2009, pp. 210–214.
- X.-S. Yang, Firefly algorithms for multimodal optimization, in: O. Watanabe, T.Zeugmann (Eds.), Stochastic Algorithms: Foundations and Applications, Vol.5792 of Lecture Notes in Computer Science, Springer, Berlin, Heidelberg,2009, pp. 169–178.
- B. Xing, W.-J. Gao, Invasive weed optimization algorithm, in: Innovative Computational Intelligence: A Rough Guide to 134 Clever Algorithms, Springer, 2014, pp. 177–181.
- C. Blum, A. Roli, Metaheuristics in combinatorial optimization: overview and conceptual comparison, ACM Comput. Surv. 35 (3) (2003) 268–308.
- M.N. Ab Wahab, S. Nefti-Meziani, A. Atyabi, A comprehensive review of swarm optimization algorithms, PLoS ONE 10 (5) (2015), http://dx.doi.org/10.1371/journal.pone.0122827.
- Mukherjee, V. Mukherjee, Solution of optimal power flow using chaotic Krill Herd algorithm, Chaos Solitons Fractals 78 (2015) 10–21.
- G. Wang, L. Guo, H. Wang, H. Duan, L. Liu, J. Li, Incorporating mutation scheme into krill herd algorithm for global numerical optimization, Neural Comput.Appl. 24 (3–4) (2014) 853–871.
- L. Gharavian, M. Yaghoobi, P. Keshavarzian, Combination of Krill Herd algorithm with chaos theory in global optimization problems, in: 3rd Joint Conference of AI & Robotics and 5th RoboCup Iran Open International Symposium (RIOS), IEEE, 2013, pp. 1–6.
- J. Amudhavel, D. Sathian, R. Raghav, L. Pasupathi, R. Baskaran, P.Dhavachelvan, A fault tolerant distributed self organization in peer to peer(p2p) using krill herd optimization, in: Proceedings of the 2015 International Conference on Advanced Research in Computer Science Engineering &Technology (ICARCSET 2015), ACM, 2015, p. 23.
- B. Mandal, P.K. Roy, S. Mandal, Economic load dispatch using Krill Herd algorithm, Int. J. Electr. Power Energy Syst. 57 (2014) 1–10.

Thanks for your
kind attention!